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GEOLOGY AND PALEONTOLOGY.

The Strength of the Earth's Crust.—The term crust is here used to indicate the outside part of the earth, without reference to the question whether it differs in constitution from the interior.

Conceive a large tank of paraffine with level surface. If a hole be dug in this and the material be piled in a heap at one side, the permanence of hole or heap will depend on its magnitude. Beyond a certain limit, further investigation and heaping will be completely compensated by the flow of the material. Substitute for paraffine the material of the earth's crust, and the same results will follow, but the limiting size of the hole or heap will be different, because the strength of the material is not the same. Assuming the earth to be homogeneous, the greatest possible stable prominence or depression is a measure of the strength of its material.

It is not believed that the earth is homogeneous, and with reference to the outer portion of the crust it is known that it is not composed of homogeneous shells. There is observational basis for the theory that the matter composing and lying beneath ocean beds and continents is lighter than the matter composing and lying beneath ocean beds, and many students of terrestrial physics entertain the theory that unit columns extending from the surface downward have everywhere the same weight, the height of each column being inversely as its mean density. In accordance with this theory, prominences and depressions of the surface exist in virtue of a principle of equilibrium, called isostatic.[1] Under hydrostatic equilibrium the surface of a free liquid is level; under isostatic equilibrium the surface of a non-homogeneous solid capable of viscous flow, is uneven.

There are thus two possible explanations of the inequalities of terrestrial surface, and these may be characterized severally by the terms rigidity and isostasy.

In connection with a study of Lake Bonneville, a large body of water temporarily filling a basin of Utah during Pleistocene time,[2] observational data were gathered bearing on the question of rigidity versus isostasy.

[1] For definitions of the new term "isostasy" and its adjective "isostatic," see Dutton in Bull. Phil. Soc., Washington, XI., p. 53, and Woodward in *Am. Jour. Sci.*, 3d Series, Vol. XXXVIII, 1889, p. 351.

[2] An account of Lake Bonneville may be found in the Second Annual Report of the U. S. Geological Survey, 1881, pp. 167-200.

1. The Wasatch mountain range is carved from a large block of crustal material, uplifted along a fault plane at one side. The block adjoining the fault plane on the opposite side is thrown down. Erosion s continually transferring material from the uplifted block to the downthrown block, and there is direct evidence that the mountain is steadily rising or the valley sinking, or both. Some advocates of the isostatic theory would regard this progressive relative displacement as a direct effect of the continual transfer of load. Under this view the mountain block has less density than the valley block, and the two are in isostatic equilibrium ; the unloading of the mountain block by erosion and the loading of the valley block by deposition disturb the equilibrium, and it is restored by vertical movement on the fault plane.

An arm of Lake Bonneville occupied the valley, filling it to an average depth of 500 or 600 feet, and this load of water was somewhat quickly added and afterward somewhat quickly removed. If the valley block were delicately sensitive to the application of load, it should be depressed about 200 feet by the access of water, and should rise a corresponding amount when the water was removed. But this did not occur. On the contrary, the depression of the valley, as shown by changes occurring along the fault plane, continued alike during the presence of the water and after its removal. It is therefore concluded that the local transfer of load from one orognic block to the other is not the primary cause of the progressive rise of the mountain and depression of the valley, and the question arises whether the mountain range may not be wholly sustained in virtue of rigidity.

2. Considering the main body of Lake Bonneville, it appears from a study of the shorelines that the removal of the water was accompanied, or accompanied and followed, by the uprising of the central part of the basin. The coincidence of the phenomena may have been fortuitous, or the unloading may have been the cause of the uprising. Postulating the casual relation, and assuming that isostatic equilibrium, disturbed by the removal of the water, was restored by viscous flow of crust matter, then it appears (from the observational data[3]) that the flow was not quantitatively sufficient to satisfy the stresses created by the unloading. A stress residium was left to be taken up by rigidity, and the measure of this residium is equivalent to the weight of from 400 to 600 cubic miles of rock.

From these phenomena and theoretic considerations arises the working hypothesis that the measure of the strength of the crust is a prominence or a concavity about 600 cubic miles in volume.

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[3] These data are not yet fully published, but will appear in a memoir on Lake Bonneville now in press, constituting Vol. I. of the Monographs of the U. S. Geological Survey.

If this hypothesis is strictly true, then there should be no single mountain mass and no single valley, due purely to the local addition or subtraction of material, having a greater volume than 600 cubic miles. At least four kinds of mountains and valleys are due simply to the addition and subtraction of material: (1) mountains of extravasation (such as volcanic cones), beneath which the pre-existent terranes lie undisturbed; (2) mountains of circumdenudation, produced by the removal of surrounding material; (3) mountains produced by extravasation *and* circumdenudation; (4) valleys of erosion, unaccompanied by phenomena of displacement.

A large number of such mountains and valleys exist, and some of the largest occurring in the United States have been mapped in contours by the U. S. Geological Survey, so that their volumes can be computed readily.

San Francisco Mt., in Arizona, a result of extravasation, has a volume of 40 cubic miles.

Mt. Shasta, probably due to extravasation only, has a volume of 80 cubic miles.

The Tavaputs Plateau, or Roan Mt., lying on the borders of Utah and Colorado, and produced by circumdenudation, has a volume of 700 cubic miles.

Mt. Taylor, and the Taylor Plateau, in New Mexico, resulting from extravasation and circumdenudation, have jointly a volume of 190 cubic miles.

The Henry Mts., resulting from volcanic intrusion and circumdenudation, have a volume of 230 cubic miles.

The Sierra La Sal, a mountain group of the same type, has a volume of 250 cubic miles.

The deeper portion of the Grand Cañon from the Colorado, from the mouth of the Little Colorado to the mouth of Kanab Creek, is due to the removal of 350 cubic miles of rock.

The Tavaputs Plateau slightly exceeds the hypothetic limit; the other illustrations fall within it.

In view of the phenomena cited, and of the considerations and comparisons adduced, it is believed that the following theorem or working hypothesis is worthy of consideration and of comparison with additional facts: *Mountains, mountain ranges, and valleys of magnitude equivalent to mountains, exist generally in virtue of the rigidity of the earth's crust; continents, continental plateaus, and oceanic basins exist* *in virtue of isostatic equilibrium in a crust heterogeneous as to density.*—G. K. Gilbert, in *Bulletin. Geol. Soc. America.*

Scott and Osborn on the Fauna of the Brown's Park Eocene.[1]—This memoir supplies an important desideratum, since we obtain through it the first intelligible view of the Mammalian fauna of the Brown's Park or Uinta (name preoccupied) horizon of the Eocene of North America. This formation, as is well known, occupies the summit of the Eocene series, and therefore intervenes between the Bridger below and the White-River above. The faunæ of the last-named horizons are tolerably well known, while for the Brown's Park series we have had to depend hitherto on the exceedingly unsatisfactory descriptions published by Marsh many years ago. The formation has, so far as known, a limited geographical extent, occurring at the south base of the Uinta Mountains in N. E. Utah only. This location was explored by the Princeton party under Professor W. B. Scott, whose observations on the geology constitute the introduction to this memoir.

The paleontological part of the memoir is an excellent model of what such a work ought to be, and the results are worthy of the care bestowed on its preparation. The species observed are eleven in number, which belong to as many genera. These are as follows: *Quadrumana,* Hyopsodus; *Glires,* Plesiarctomys; *Creodonta,* Mesonyx and Miacis; *Perissodactyla,* Epihippus, Diplacodon, Isectolophus, Amynodon and Triplopus; *Artiodactyla,* Protoreodon and Leptotragulus. Of these genera, Isectolophus, Protoreodon, and Leptotragulus were discovered by the Princeton expedition. Nothing of unusual novelty is stated with regard to the species and genera of the Quadrumana, Glires, and Creodonta, but the case is quite different with regard to the Ungulata. Ancestral forms of later types are here most distinctly indicated, and the authors must be congratulated on the important contribution they have thus made to the doctrine of evolution. They show that Epihippus stands in the line of the horses, as asserted by Marsh, but, unlike that author, they satisfactorily demonstrate that it intervenes between Pliolophus and Anchitherium. They also show that Diplacodon is the ancestor of the varied forms of the Menodontidæ of the lower Miocene, and the descendant of Palacosyops of the Bridger Eocene. Isectolophus is proven to be the parent of the tapirs, connecting that type with Systemodon, through some intermediate forms, as suggested by the present writer.[2] Amynodon is fully elucidated as far as cranial structure goes, and its relation to the primitive rhinoceroses pointed out. A new Triplopus (*T. obliquidens* S. & O.) is described, which is of larger size than the *T. cubitalis* of the Bridger, and the knowledge of the character of the genus is increased. Protoreodon S. & O. is of especial interest. It is essentially an Oreodont with the fifth crescent (metaconule) of the superior molar present as in the Eocene Artiodactyla generally. It is so much like Oreodon in other respects as to indicate its place as ancestral to that form, and it adds one more piece of evidence to sustain the view that the tetraselenodont forms are the descendants of the pentaselenodont Artiodactyla. The *Protoreodon parvus* S. & O. was an animal about the size of a raccoon. Leptotragulus is an equally interesting form, since it supplies the hitherto missing ancestor of Poëbrotherium. It is tetraselenodont, and differs chiefly from the latter and later genus in the freedom of the ulna and radius from each other. Thus the genera of Ungulata of this formation extend the phylogenetic lines by one period backwards, or they fill gaps hypothetically awaiting occupation.

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[1] The Mammalia of the Uinta Formation. Part I., The Geological and Faunal Relations, and Part II., the Creodonta, Rodentia and Artiodactyla, by W. B. Scott; Part III., The Perissodactyla, and Part IV., The Evolution of the Ungulate Foot, by H. F. Osborn. Transactions of the American Philosophical Society, Philadelphia, 1889, Vol. XVI., p. 461; pl. V.; p. 112.

The chapter on the evolution of the Ungulate foot, by Prof. Osborn, handles the subject in a masterly way. The author admits the fundamental propriety of the system proposed by Cope, but takes some exception to an application of it in detail in certain directions. The exception on which most stress is laid is the fact that in the equine line, after the development of diplarthry in the posterior foot, a tendency to revert to taxeopody appears. Prof. Osborn states that the above-mentioned system becomes here "not strictly applicable;" but as he has not demonstrated a return to absolute taxeopody, and as he admits the fundamental conformity of the system to nature, the objection cannot be said to have much weight. The condition in Equus shows only the effect of the increased dimensions of the median digit and the corresponding elements of the second tarsal row, to which the first tarsal row does not fully correspond.

Prof. Osborn also objects to Cope's theory of the origin of diplarthry by torsion, stating with reason that were this the only movement, the metarso-tarsal articulation cannot be accounted for. In other words, were the tarsus and carpus to be rotated externally on the metatarsus and metacarpus,[8] dislocation of their articulation would take place. Prof. Osborn called my attention verbally to this point, and as I had not previously considered it, I supplied what I thought to be an adequate explanation in my late memoir in *The American Journal of Morphology.*[3] This was based on the fact already recorded by Allen in his analysis of the Muybridge photographs, that in recover the weight is borne on the inner edge of the foot, and therefore on the external sides of the heads of the metapodials. I did not then state with sufficient clearness what I now add, that the external torsion of the lower leg concerned in producing diplarthry is that which occurs, as I have pointed out, at recover, and it is therefore coincident in time with the transfer of the weight to the inner side of the foot, so that both strains occur together, and so dislocation cannot occur. In rapid movement, when the torsion-strain is most energetic, all the strains will be nearly contemporaneous; while in slow movements the torsion on plantation will be distinct, if existing, of which there is some doubt. Thus is directed and located the growth-energy, to which Prof. Osborn appeals as a sufficient explanation of the phenomenon of diplarthry.

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[2] Article Perissodactyla, AMER. NATURALIST, 1887, December.

The authors in a few instances, through some oversight, have misstated the opinions of the present reviewer. Thus Prof. Scott cites him as having regarded the genera Amynodon and Metamynodon as identical. This he has not done, as can be seen by his systematic descriptions of the two genera in "The Perissodactyla," (NATURALIST, 1887, p. 993). Prof. Osborn quotes my earlier proposition of 1885, that Triplopus is in the phylum of the rhinoceroses, and omits to mention the modified view expressed in "The Perissodactyla" (1888), that it is in the line of Hyracodon, and at one side of the rhinoceroses. The slender legs of the known species of this genus are, however, not to be regarded as a generic character, as is done by Osborn, and a stout-legged Triplopus is by no means an impossibility. Finally, Osborn accuses me of regarding carpal and tarsal displacement as having preceded in time digital reduction, because I stated that one consequence of displacement had been the loss of the inner digit. This accusation is quite inexcusable, as I have never thought it necessary to express any opinion on the subject. Phenacodus (with which I am somewhat familiar) shows that reduction preceded displacement, to say nothing of Hyrax, cited by Osborn. Reduction followed disuse, and it is only the inner digit that has suffered finally through displacement.—E. D. COPE.

Note on the Pelvis of Cumnoria (Camptosaurus).—In a recent examination of Mr. Lydekker's admirable volume on vertebrate paleontology, I was struck with the conspicuous perpetuation of an error which should have been corrected before now. On page 1152, referring to the Ornithopoda he says: "The ilium generally has its preacetabular process much elongated, although this is not the case in the type of *Camptosaurus;*" and on page 1158, "The posterior portion of the ilium of this species [*Iguanodon fittoni*] is indeed almost indistinguishable from that of *Camptosaurus.*" If one will compare the figure of the pelvis of *Camptosaurus dispar* on page 1153 with that of *Iguanodon dawsoni* on page 1158, he will be struck with the strong resemblance throughout, except of the anterior portion of the ilium." The fact is that the figure of the former is wrong. The anterior portion of the ilium of the type had been broken off and weathered, indications of which are distinctly seen in the specimen. Prof. Marsh had this demonstrated to him more than five years ago, and there are other ilia in the Yale Museum in which this process is complete. It is to be hoped that this figure will be banished from text-books in the future, and that no new genus will be made on the supposition that the process is wanting.—S. W. Williston.

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[3] On the Mechanical Origin of the Hard Parts of the Mammalia, 1889, p. 171.

BOTANY.

The Assimilation of Carbon by Green Plants from Certain Organic Compounds.—Under this title Mr. E. Hamilton Acton publishes in the Proceedings of the Royal Society (Vol. XLVII., p. 150) the results of an interesting series of experiments made by him to determine whether it can be produced in the assimilating cells of green plants when supplied with certain organic compounds, in the absence of carbon dioxide from the air. The following summary will give the essential parts of the paper.

The apparatus used consisted of a tall bell-jar, perforated at the top, and accurately ground at the bottom. Into the top an india-rubber stopper was accurately fitted, and through this were passed two bent glass tubes, each leading to a U tube filled with soda-lime. Inside of the bell-jar were placed a glass culture cylinder, a small dish of soda-lime, a couple of dishes of water, and a test-tube filled with a solution of caustic potash. The bell-jar was set upon a glass plate, and the contact was rendered air-tight by the use of a mixture of vaseline, resin and beeswax.